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in

Myrta A. (ed.), Di Terlizzi B. (ed.), Savino V. (ed.).
Virus and virus-like diseases of stone fruits, with particular reference to the Mediterranean region

Bari : CIHEAM
Options Méditerranéennes : Série B. Etudes et Recherches; n. 45

2003
pages 9-13

CORRELATION BETWEEN BREEDING TECHNIQUES AND GAMIC TRANSMISSION OF VIRUSES IN FRUIT TREE CROPS

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SUMMARY - Many viruses and viroids of plants are reported to be pollen and seed transmitted. Their presence in many varietal collections of fruit trees used as source materials for genetic breeding (pollen or seeds) makes extremely urgent a need to establish appropriate protocols to exclude, or otherwise check them to avoid the diffusion with propagating material. Avoiding the use of infected mother plants or eliminating them is not always the best practice. Although it may be mandatory by law, their destruction might entail the irretrievable loss of particularly valuable genetic material with no chance of being recovered. In such cases, the genetic uniqueness of the infected material would make its sanitation imperative, to avoid compromising the breeding programme irreparably. However, during sanitation step, germplasm has to be kept in isolation conditions (glass houses or insect proof screen houses) and compulsory with quarantine agents. Available diagnostic methods are sensitive and reliable, and their continuous evolution leads to consider even further refinement and application simplifications for the future. These methods have already greatly favoured fruit trees nursery production, allowing a punctual and continuous monitoring of plant material along the different phases of the breeding process. A better co-operation between complementary scientific disciplines is highly desirable in this field also.

Key words: fruit tree viruses, virus transmission, plant breeding, plant propagating material

RESUME *- Bon nombre de virus et de viroïdes des végétaux sont censés être transmissibles par le pollen et la graine. Vu leur présence dans plusieurs collections variétales d'espèces fruitières, utilisées comme source de matériel pour l'amélioration génétique (pollen ou graines), il serait nécessaire de mettre en œuvre, aussitôt que possible, des protocoles appropriés pour les éliminer ou du moins les contrôler, empêchant ainsi leur diffusion à travers le matériel de multiplication. Eviter l'utilisation de pieds-mères infectés ou les arracher ne constitue pas toujours la meilleure pratique. Il serait possible d'imposer par la loi l'éradication de ces plants, mais leur destruction risquerait de causer la perte irréparable de matériel génétique de grand intérêt, qui ne pourrait pas être récupéré autrement. De ce fait, compte tenu de la particularité génétique du matériel infecté, l'assainissement deviendrait un impératif pour ne pas compromettre la réussite du programme d'amélioration. Cependant, au cours de la phase d'assainissement, le matériel génétique doit être maintenu dans des conditions d'isolement (en serre ou bien dans une cage grillagée insect-proof) qui deviennent une exigence incontournable quand on a affaire aux organismes de quarantaine. Les méthodes de diagnostic disponibles actuellement sont sensibles et assez fiables et leur évolution continue nous incite à penser qu'à l'avenir, elles seront de plus en plus fines et simplifiées. Ces méthodes ont déjà grandement favorisé la production de pépinière des espèces fruitières, permettant ainsi un suivi ponctuel et continu du matériel végétal tout au long des différentes phases du processus d'amélioration. Par ailleurs, il serait utile d'encourager la coopération et la complémentarité des diverses compétences scientifiques impliquées dans ce domaine.*

Mots-clés: *virus des espèces fruitières, transmission des virus, amélioration des plantes, matériel végétal de multiplication*

INTRODUCTION

Seed and, to a lesser extent, pollen are the natural pathway through which plant intracellular pathogens like viruses and viroids are transmitted to the progeny of hosts (vertical transmission) and spread to the environment. Many bibliographical publications illustrate the mechanisms underlying transmission and the problems it causes, and we suggest that you should refer to the latest ones (Mink, 1993; Johansen *et al.*, 1994; Maury *et al.*, 1998) for bibliographical reference.

Seed transmission is an intrinsic property of the members of at least 25 of the virus genera presently known, while a dozen cases have been reported in viroids. A few years ago, Stace-Smith and Hamilton (1988) reported that about 18% of viruses known at the time could be seed transmitted in one or more hosts and the estimate was that one third of the population of plant viruses was able to follow the same path in at least one host. The situation is therefore far from being encouraging, especially if we consider that, generally speaking, seed transmission is supported by other methods of diffusion (by vectors, for instance) which highly increase the efficiency of virus dissemination in nature.

Although in general seed transmission occurs more frequently in herbaceous crops rather than in the woody plants which make to object of this study, in the case of herbaceous crops this is not an obstacle to genetic breeding, because it is actually quite easy to find healthy parent material, and selection occurs on a high number of individuals, which are largely virus-free.

In case of fruit trees (in a broad sense, including the grapevine and olive), on the contrary, the presence of viruses and viroids in many variety collections used as a source of material for genetic breeding (pollen or seeds) makes it extremely urgent to set up appropriate protocols to exclude, or anyway check, the presence of agents that might compromise the sanitary status and therefore the diffusion of propagating material. It is known that healthy plants (free from pathogenic viruses) offer better opportunities in terms of vegetative development, are less susceptible to other diseases and have a higher productivity and fruit quality (see among others Jakubczyk *et al.*, 1997).

Although it has apparently been assessed that the *Plum pox virus* (PPV), the agent of Sharka, by far the most dangerous virus affecting stone fruit trees, is not seed transmitted (Myrta *et al.*, 1998; Pasquini *et al.*, 2000), it is well known that other viruses are very much widespread in these species. These include the agents of *Apple mosaic virus* (ApMV) in almond, *Prune dwarf virus* (PDV) in cherry, *Prunus necrotic ring spot virus* (PNRSV) in peach, cherry and plum, and *Apple chlorotic leaf spot virus* (ACLSV) in apricot (Desvignes, 1999), affecting commercial orchards with infection incidence that may reach 80%. Some do spread by pollen and/or seed.

In particular, viruses to be closely monitored are: (a) in stone fruits, ilarviruses PDV and PNRSV, both seed transmitted with percentages varying from 2 to 90% and, the second one in particular, pollen transmitted as well; *Cherry leaf roll virus* (CLRV) transmitted to the walnut tree by seed and pollen also to mother plants and Strawberry latent ring spot virus (SLRSV); (b) in the grapevine, *Grapevine Bulgarian latent virus* (GBLV) and *Peach rosette mosaic virus* (PRMV), while far less concern is provoked by *Grapevine fan leaf virus* (GFLV), which is present both in the endosperm and in pollen, but is very rarely transmitted to seedlings. A potential danger might be that of *Grapevine rupestris stem pitting associated virus* (GRSPaV) which is present in pollen; (c) in the olive tree, CLRV and *Olive latent virus* 1 (OLV-1) whose transmission by seed has been recently confirmed (M. Saponari, T. El Beaino and V. Savino, personal communication). Citrus, on the contrary, apparently enjoy a privileged condition as none of the main viruses reported in the Mediterranean seems to be gamically transmitted to its progeny (see, among others, D'Onghia *et al.*, 2000).

As already mentioned, some viroids were reported in the pollen and seed of hosts and they also use these routes for survival and dissemination. While nothing has so far been reported on the seed transmission of *Peach latent mosaic viroid* (PLMVd), one of the most hazardous viroids of fruit trees, and *Citrus exocortis viroid* (CEVd) in citrus, this mechanism of transmission has been reported for all the five viroids of the grapevine: yellow spot 1 and 2 (GYSVd-1 and GYSV-2), *Hop stunt viroid* (HSVd), *Grapevine Australian viroid* (GAVd) and CEVd (Wan Chow Wa and Symons, 1999).

The problem therefore exists and it did not emerge recently, but two circumstances make it even more urgent. First, the scarce attention devoted in the past (even by scientific institutions) to the sanitary status of exchange plant material, contributing to the diffusion of infected plants or allowing their access to the market while waiting for healthy material to be available. Second, the issuing of national and international regulations making the spread of healthy material compulsory and leaving the responsibility to breeders. On the other hand, it is adamant that the low performances of virus affected cultivars in terms of quality and quantity make it more and more urgent, for breeders as well, to set up procedures for the use of healthy material, in all the phases of the long path leading to the breeding and diffusion of a new variety.

Here follows a list of precautions to be observed to obtain fruit crops propagation material free from infectious diseases along all the phases of the process of genetic breeding, also taking into account works already published in literature (Barba *et. al.*, 1999; Lankes, 2000; Vicchi *et al.*, 1997).

AVAILABILITY OF HEALTHY MOTHER PLANTS

The presence of infectious agents that can be spread by zygotic transmission (pollen and seed) makes it necessary to obtain seed or pollen stock free from infectious agents. This would theoretically assure the production of seeds that are totally free from infectious agents, and to use them for crossing purposes. In practice, however, this ideal condition is very difficult to achieve because:

a) mother plants are normally grown in the open field, where they are exposed to vectors. Although the hypothesis may be made to keep them under insect-proof structures, in that case plant breeding would be carried out in pots, with a consequent reduction in size and fruits and seeds yields. From the practical point of view, the breeding of mother plants under controlled conditions is viable only for the collection of pollen, obtainable also from small plants;
b) it is no easy task to make a very early forecast of when a given parent will be necessary, so waiting for the availability of healthy material might delay unnecessarily the use of precious genetic material for breeding purposes.

However, it should also be kept in mind that avoiding the use of infected mother plants or eliminating them is not always the best practice. Although it may be mandatory by law, their destruction might entail the irretrievable loss of particularly interesting genetic material that has no chance of being recovered. This may occur in the case of seedlings or selections obtained during breeding programmes or specimens of old germplasm that can no longer be obtained from other sources. In such cases, the genetic uniqueness of the infected material would make its sanitation imperative, to avoid compromising the continuation of the breeding programme irreparably. However, while awaiting sanitation to be performed, germplasm must be kept in isolation conditions (glass houses or insect proof screen houses) which is compulsory for quarantine pests, for instance.

CONTROL OF THE SANITARY STATUS OF PROGENY

Seeds

Seed transmission depends on the ability of a virus to invade and replicate in the reproductive tissues of its host and to overcome without damage the physiological modifications associated to seed maturation. In case this occurs, the virus is embedded in the seed where it can have different localisation (integument, endosperm, embryo). This is not irrelevant, as only the invasion of the embryo causes the transmission of the virus to the seedling and, therefore, its actual transfer to the progeny. As a consequence, not all seeds containing viruses generate infected plants, therefore it is absolutely necessary to test seeds dissected in their components to assess the potential seed transmissibility of any infectious agent.

Seedlings

Compliance with the precautions indicated in the previous paragraph (use of healthy parents) may not always be viable, in particular in case of: (i) unquestionable needs of the breeding programme requiring the use of genotypes (both seed or pollen stock) for which no healthy sources exist; (ii) impossibility to place selection plots at a safe distance, away from possible sources of infection like commercial crops, a situation that is very common in Italy for the most relevant species.

Attention must moreover be paid to the spread of ornamental fruit trees in parks and gardens and to the presence of similar wild species in uncropped areas.

In case there is no choice but to resort, for crossings purposes, to one or both parents that are affected by pollen- or seed-transmitted pathogens, it is necessary to assess the sanitary status of the seedlings over their very first vegetative stages (after emergence of the third-fifth leaf). This must be done with serological (ELISA) or molecular methods (single or double stage PCR) (Martelli, 1999), in order to exclude infected individuals immediately. It is also advisable, prudentially, to repeat the assay a few months later, to give to viruses which might have escaped the first analysis time enough to multiply and reach a detectable concentration. Besides, even in case seedlings come from parent material grown with any possible precaution and believed to be healthy, it is necessary to check their sanitary status in the plot where they are grown.

Practical reasons relating to the very high number of seedlings grown make it quite difficult to perform a careful sanitary observation and evaluation, even considering that the majority of seedlings is fated to a quite short life (3 to 5 years for peach and 7 to 8 for European plum and apple). Very simple precautionary measures would require the immediate elimination of subjects that will not be used for multiplication, without waiting for the evaluation of the whole selection plot (all seedlings entering production). This is due to the fact that their fruit-bearing phase is not simultaneous, given the heterogeneity that makes them unique individuals.

CONTROL OF THE SANITARY STATUS OF SELECTIONS

When choosing a seedling for the multiplication phase (once it has been judged interesting in one of its aspects), a few precautions have to be observed. First of all, visual examination must exclude the patent presence of virus diseases and laboratory and biological testing (indexing) must provide further evidence of the sanitary status of the seedling. Various routes may then be followed for the multiplication of the selected seedling, according to the response obtained from diagnostic analysis:

a) in case laboratory assays are negative, the seedling may be multiplied in the nursery, awaiting the outcome of biologic indexing. In case indexing is available before vegetative recovery following grafting, the infected material will be removed from the nursery. In case the results of indexing are not known before the vegetative recovery of the grafted plant, and there are grounded suspicions leading to believe in the presence of aphid transmitted infectious agents, it is advisable to pot temporarily the multiplied plants and keep them in quarantine insect proof facilities;
b) in case laboratory assays are positive, the destination of the selection may depend upon the danger of the infectious agent. In case it is a virus that is subject to compulsory control (stone fruit PPV or citrus CTV, for instance) the breeder will have to evaluate the opportunity to proceed to the elimination of the selection or choose to sanitise it before introduction in the open field. This decision will of course also be based on the relation between expected costs and pomological value of the selection;
c) in case laboratory and biological assays show the presence of seed or pollen transmissible agents causing no particular hazard, it will first of all be necessary to weight the opportunity to sanitise before continuing the selection. It is important to be aware of the fact that it will be necessary to take action before the material is sold or provided to a third party;
d) in case indexing is negative too, the subjects will be free to be placed in the open field.

SUGGESTIONS FOR THE PROPAGATION OF SELECTED MATERIAL

Irrespective of what has been specified in the previous paragraph, the propagation of selected material must occur keeping in mind the need to: (i) use certified rootstocks (when propagation occurs by grafting); (ii) place and keep at least two healthy plants for each genotype in insect and nematode free facilities for the whole phase of selection.

At the end of the selective phase (which often requires at least two different steps of selection, and then of propagation and of growth in the field) 8 to 10 years elapse, with the consequence of possible re-infection in the field. This situation would *de facto* make it impossible, in the marketing phase, to be able to distribute the multiplication material of validated species, unless a few individuals have been kept in conditions of sanitary protection right from the start of the selection process.

CONCLUSIONS

The danger to incur in sanitary problems during the process of genetic breeding is very up to date and to be seriously taken into account. In the past, due to less advanced knowledge of the ecology of fruit trees viruses and to the scarce interest shown by breeders in sanitary issues, geneticians and virologists did not co-operate as they are doing today. The awareness that virus infections are widespread and hazardous (the case of Sharka is tale telling) and that they can jeopardise years of activities and study, as well as the existence of legislation (CAC, certification) imposing compliance with sanitary standards, are strong enough drives to look for synergies with the aim of reducing or eliminating risks. Diagnostic methods available today are sensitive and reliable enough, and their continuous evolution leads to think of even further refinement and application simplifications for the future. These methods have already greatly favoured fruit trees nursery production (Martelli, 1999), allowing a punctual and continuous monitoring of plant material along the different phases of the breeding process. In Italy the conditions to reach a further co-operation between different but undoubtedly complementary scientific disciplines do exist, and this is to be taken into due consideration. Examples are before our eyes, and if they are able to set the standard, our scientific future will be certainly brighter.

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VIRUS DISEASES AFFECTING THE MEDITERRANEAN STONE FRUIT INDUSTRY: A DECADE OF SURVEYS

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SUMMARY - The sanitary status of the Mediterranean stone fruit industry is discussed, based on extended surveys carried out during the 1990s, i.e.in Albania, Italy (Apulia), Jordan, Lebanon, Malta, Palestine, Syria, Tunisia and Turkey (East-Anatolia). Sweet cherry was the most virus-infected crop (54% of the trees were infected by at least one virus) whereas apricot was the least infected (10%). Peach, plum and almond had infectin of 33%, 28% and 27% respectively. *Plum pox virus* (PPV), *Prunus necrotic ringspot virus* (PNRSV), *Prune dwarf virus* (PDV), *Apple mosaic virus* (ApMV*)* and *Apple chlorotic leaf spot virus* (ACLSV) were the important stone fruit viruses detected.

Key words: Mediterranean, stone fruits, PPV, PNRSV, PDV, ACLSV, ApMV

RESUME *- L'état sanitaire des espèces fruitières à noyau méditerranéennes est passé en revue, en s'appuyant essentiellement sur les résultats des prospections effectuées tout au long des années 90. Les prospections ont été réalisées en Albanie, Italie (Pouilles), Jordanie, au Liban, à Malte, en Palestine, Syrie, Tunisie et Turquie (Anatolie orientale). Le merisier était la culture la plus infectée par les virus (54% des arbres étaient infectés par au moins un virus), alors que l'abricotier était le moins infecté (10%). Quant au pêcher, au prunier et à l'amandier, le taux d'infection était de 33%, 28% et 27%, respectivement. Le Plum pox virus (PPV), le Prunus necrotic ringspot virus (PNRSV), le Prune dwarf virus (PDV), l'Apple mosaic virus (ApMV)et l'Apple chlorotic leaf spot virus (ACLSV) se sont avérés être les virus les plus importants chez les espèces fruitières à noyau dans la région.*

Mots-clés**:** *Méditerranée, espèces fruitières à noyau, PPV, PNRSV, PDV, ACLSV, ApMV*

INTRODUCTION

The Mediterranean region produces about 40% of the world supply of stone fruits. Almond and apricot are the most important crops contributing 50% and 45% of the total production, respectively. The cultivation of stone fruits in the Mediterranean is still broadly based on a high number of local varieties as every country possesses its own germplasm, important especially for domestic market (Bassi and Pirazzoli, 1998).

In this paper, the sanitary situation of the Mediterranean stone fruit industry is discussed, based on results of extended surveys in several countries during the 1990s by personnel at the Mediterranean Agronomic Institute, the University of Bari and local institutions.

REPORTED VIRUSES

Prunus spp. are affected by many viruses, the most frequent occur in the genera *Ilarvirus, Potyvirus* and *Trichovirus*. The following are the most important: *Plum pox virus* (PPV), *Prunus necrotic ringspot virus* (PNRSV), *Prune dwarf virus* (PDV), *Apple mosaic virus* (ApMV*)* and *Apple chlorotic leaf spot virus* (ACLSV). Nepoviruses are generally less frequent in the region and are reported mainly from the Northern shore (France, Italy, etc), i.e. Strawberry latent ringspot virus (SLRSV), *Myrobalan latent ringspot virus* (MLRSV) and *Raspberry ringspot virus* (RpRV).

Sharka, caused by PPV, is by far the main virus disease of stone fruits in the region, being widespread (Albania, Greece, ex-Yugoslavia) or well established (France, Italy, Spain) in the Northern rim, but occurring in the South in restricted areas (Jordan, Syria) or not at all (Israel, Lebanon, Morocco, Palestine, Tunisia). The severity of the symptoms varies according to the *Prunus* species and cultivar, the virus strain, season and location. The disease causes blotches and/or deformations in the fruits of apricot, plum and peach, and severe fruit dropping in susceptible plum and apricot varieties. Four strains of the virus, with differences in biological, serological, molecular and epidemiological behaviour have been identified: Marcus (PPV-M), Dideron (PPV-D), El Amar (PPV-EA) and Cherry (PPV-C). The virus strains recorded most frequently in the region are PPV-D and PPV-M, whereas PPV-EA has been recorded only from Egypt (Myrta *et al*., 1998). Strain PPV-M, which has been present for long time only in Eastern-European countries, became established during the 1990s in Southern France and Northern Italy causing severe damages to the peach industry. PPV-M was reported recently from Southern countries such as Jordan and Syria (Al Rwahnih *et al*., 2000; Ismaeil, 2001).

Other viruses, belonging to the genera *Foveavirus, Closterovirus*, *Ilarvirus*, *Nepovirus,* etc. have been recorded occasionally, but there is no information on their incidence and economic importance. Stem-pitting disease was reported by several authors in different stone fruit species (Ragozzino and Caia, 1968; Agrios, 1971; Quacquarelli and Savino, 1980; Di Terlizzi and Savino, 1995). The disease has still an unclear aetiology, even if a *Closterovirus* was found associated with apricot stem-pitting in Italy (Abou Ghanem-Sabanadzovic *et al*., 2001). *American plum line pattern virus* (APLPV) was reported recently in Japanese plum trees from Albania, Italy and Tunisia (Myrta *et al*., 2002), whereas Apricot latent virus (ApLV) was found in France, Italy (Gentit *et al*., 2001b) and Palestine (Abbadi *et al*., 2003). In addition, two different nepoviruses were reported in France: *Stocky prune virus* (StPV) in plum by Candresse *et al.* (1998) and *Apricot latent ring spot virus* (ALRSV) in apricot by Gentit *et al.* (2001a).

SANITARY STATUS OF DIFFERENT STONE FRUIT CROPS

Surveys were done during the 1990s in stone fruit-growing areas of Albania, Italy (Apulia), Jordan, Lebanon, Malta, Palestine, Syria, Tunisia and Turkey (East-Anatolia). In the course of the studies, the sanitary status of the crops (Table 1) was evaluated by ELISA (Savino *et al*., 1991; Di Terlizzi *et al*., 1992; Choueiri *et al*., 1993; Jawhar *et al*., 1996; Edhib, 1996; Myrta *et al*., 1996; Zeramdini *et al*., 1996; Gatt *et al*.*,* 1998; Sipahioglu *et al*., 1999; Al Rwahnih *et al*., 2001; Amenduni *et al*., 2001; Ismaeil*,* 2001; Jarrar *et al.,* 2001). During our comparative analysis we included data reported from the above papers.

Table 1. Incidence of virus infection in different stone fruit species in some Mediterranean countries (%)

Country	Stone fruit crops				
	almond	Apricot	cherry	peach	plum
Albania	16	12	56	43	47
Italy (Apulia)	86	35	58	35	25
Jordan	14	11	10	18	10
Lebanon	21	5	45	24	18
Malta	4	74	n.t.	62	63
Palestine	15	3	14	16	20
Syria	14	6	16	24	5
Tunisia	34	5	10	15	12
Turkey (East Anatolia)	33*	0.3	21	15*	n.t.

*low number of tested trees; n.t. not tested

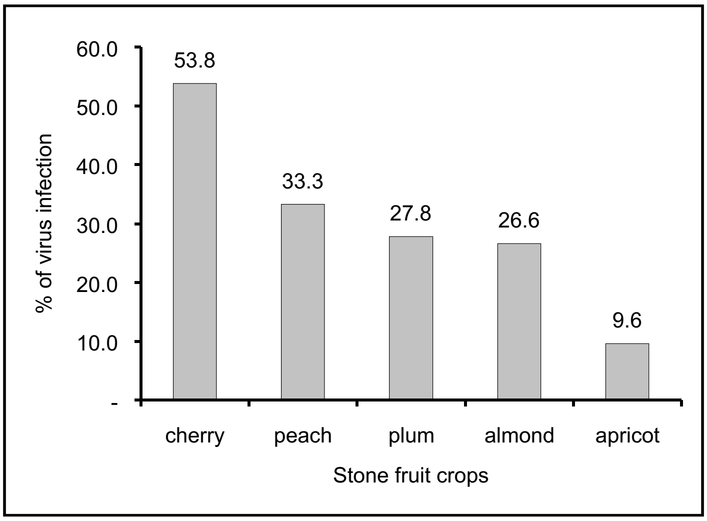

Fig. 1. Sanitary status of stone fruit trees in the Mediterranean

Almond

The major and most widespread virus-induced disorder of almond in the Mediterranean is a complex called mosaic, and characterised by a variety of symptoms ranging from bright chrome-yellow (calico) to chlorotic discolorations, localised necrosis of the leaf blade, leaf curling, bud failure, fasciations, rosetting, stunting and bushy growth. Three ilarviruses, ApMV, PDV and PNRSV, associated with almond mosaic throughout the Mediterranean, are involved to different extents in its aetiology (Martelli and Savino, 1997).

Virus-infected almond trees ranged from 4% in Malta up to 86% in Southern Italy, but the mean infection was 26.6% (Fig. 1), the most frequent infection rate ranging between 15 and 33%. The most common viruses were PNRSV and PDV. ACLSV and ApMV were found more rarely, the latter occurring with a high incidence only in Italy. PPV was never detected in almond (Fig. 2).

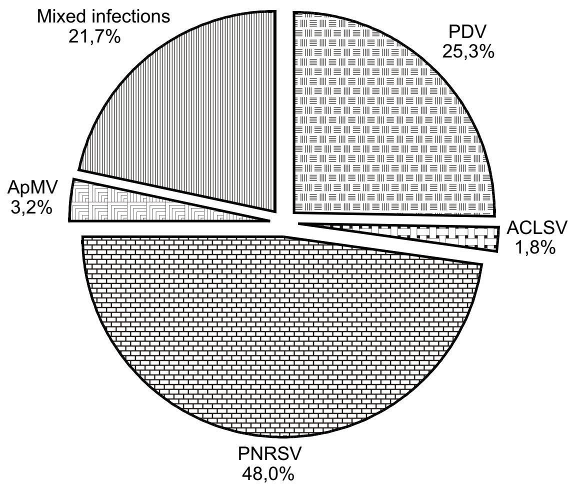

Fig. 2. Relative incidence of viruses in the almond industry

Apricot

Sharka is the main disease of apricot, notwithstanding the low rates of infection encountered generally in apricot, as compared with plum and peach. PPV-D strain was identified in apricot (especially in Spain, France, Italy) as well as PPV-M (prevailing in Greece, Cyprus, Turkey), whereas PPV-EA was reported from Egypt. Other frequent Mediterranean apricot viruses are PNRSV, ACLSV and PDV, which are found in symptomatic and symptomless trees. Among different apricot diseases caused by these viruses there is "butteratura" from Italy (Ragozzino and Pugliano, 1974) and "viruela" from Spain (Peña-Iglesias and Ayuso, 1975; Cañizares *et al.*, 2001), both caused by strains of ACLSV. The economic impact on the crop is similar to PPV, but the disease is not epidemic. Strains of PNRSV may also affect the quality of the fruits eliciting discoloured rings or spots, and occassionally necrotic line pattern.

Virus infection in apricot was less than 1% in East-Anatolia (Turkey) where the industry is based on a few local cultivars, and very high (74%) in Malta. The mean level of infection was 9.6%, the lowest among stone fruit crops (Fig.1). In the majority of the countries infections ranged from 5 to 12% (Table 1). The main viruses were ACLSV, PNRSV and PDV. PPV-M was found in limited areas and in a few trees in Albania, Jordan and Syria. ApMV was not detected in our surveys, but reported elsewhere (Fig 3).

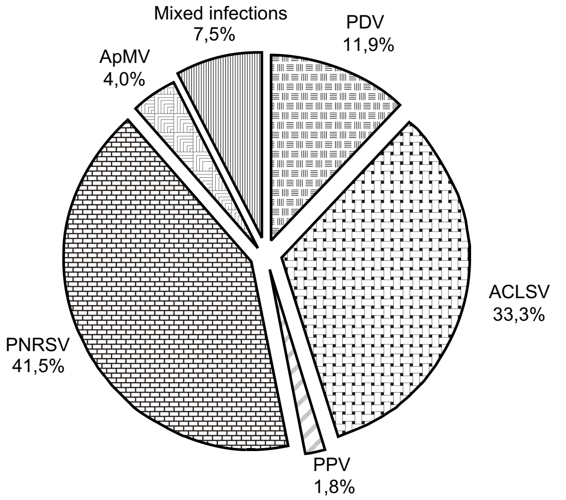

Fig 3. Relative incidence of viruses in the apricot industry

Cherry

The cherry industry is affected by many virus diseases, some are economically important. Diseased trees frequently developed chlorotic rings, chlorotic-necrotic ringspots, shot holes and yellow mosaic in the leaves, caused by PDV, PNRSV and ACLSV in single or mixed infections. Strains of these viruses were reported to cause discolorations, dark spots, pits and necrosis in the fruits (Savino, 1997; Desvignes, 1999). A few cherry trees naturally infected by PPV were reported from Southern Italy (Crescenzi *et al.*, 1994), but this finding was not confirmed

The overall infection rate was the highest (53.3%) in cherry, compared with other stone fruits (Fig.1). PDV had an incidence of 70% to 90%. ACLSV wa high (over 60%) in Albania and Palestine and ApMV (3.3%) occurred only in Southern Italy. Incidence of PNRSV was 5.9% and no PPV was detected (Fig. 4).

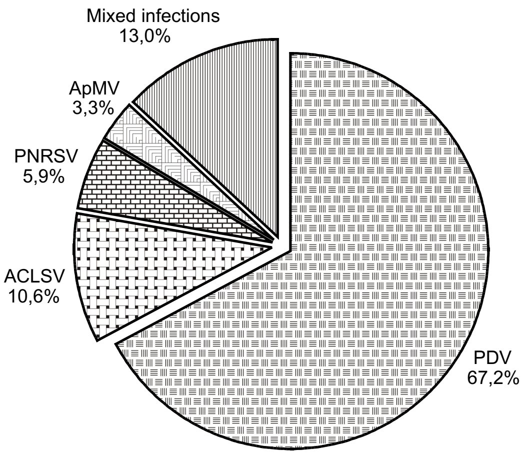

Fig. 4. Relative incidence of viruses in the cherry industry

Peach

Sharka (presence of PPV-M strain) where found, was the most destructive disease of peach affecting seriously orchards in the Northern countries (Greece, France, Italy). The peach industry of Northern Italy and Southern France (main peach producers in the region), were object of eradication programs, but PPV-M eradication efforts were largely unsuccessful, with the exception of Apulia region (Southern Italy) (Savino *et al.*, 1995). Peach stunt induces a relevant reduction in tree growth, is another frequently reported disease. This disease is associated with PDV, or mixed infections of PDV and PNRSV. Although rare, when present, nepoviruses severily affects productivity also.

Virus incidence was 15% in Tunisia and up to 62% in Malta (Table 1). Overall mean incidence in the Mediterranean was 33.3% (Fig. 1). Prevailing viruses were PNRSV and ACLSV. Mixed virus infections were more frequently in peach than in other crops. PPV-M was detected in Albania (1%) and Jordan, (2%)(Fig. 5).

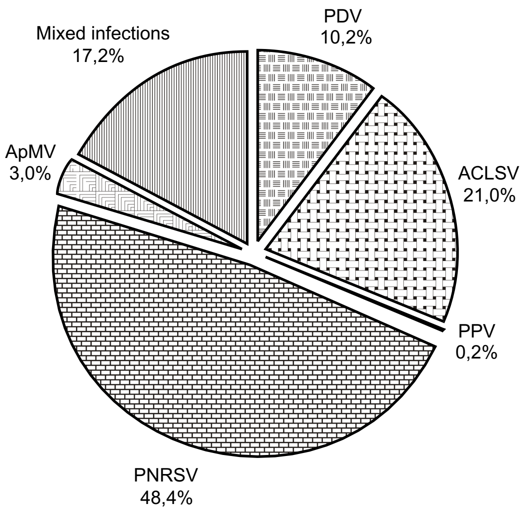

Fig. 5. Relative incidence of viruses in the peach industry

Plum

Since the first report of sharka from Bulgaria, the disease spread to Yugoslavia and Albania, where PPV infections in plum are endemic. PPV affect virtually the totality of the trees in many areas. PPV was later reported in many European-Mediterranean countries. PPV-infected trees produce poor quality fruits (deformations, flesh necrosis, low sugar and high acidity), or in many varieties suffer premature fruit drop. Leaf symptoms were chlorotic spots and rings. Another disease of plum is pseudopox (Németh, 1986), which resembles sharka, but caused by ACLSV. Savino *et al.* (1996) reported pseudopox from plum in Central Italy, and later in Southern Italy. Dwarfing (stunting) is associated with PDV alone, but more often in mixed infection with PNRSV.

Among Mediterranean countries surveyed, Syria had the lowest infection rate (5%) and Malta the highest (63%) (Table 1).The mean infection level was 27.8% (Fig.1). PNRSV, PDV and ACLSV were the most frequent viruses detected. PPV was by far the prevailing virus in Albania (59%), but detected only in two plum trees in Jordan. ApMV was not detected (Fig. 6).

A summary of viruses in the Mediterranean countries is given in Table 2.

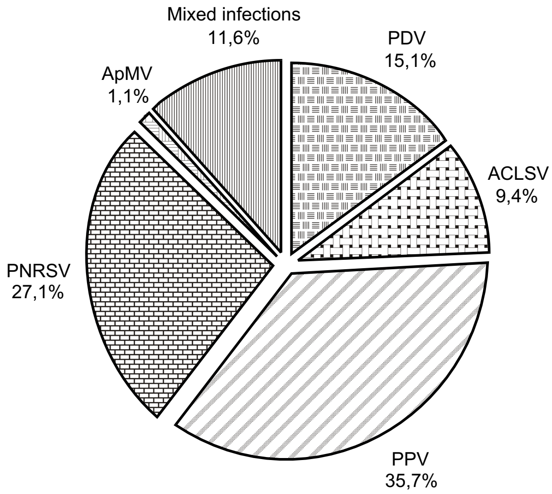

Fig. 6. Relative incidence of viruses in the plum industry

CONCLUSIONS

The general picture of the sanitary situation of the Mediterranean stone fruit industry did not change apprecially since the report by Dunez (1988) for the implementation of UNDP/FAO project RAB/86/018/A/01/12. During the '90s, sharka leapt across the ocean into Chile, USA and Canada. Also severe PPV strains spread in Southern France and Northern Italy. This presumably occurred due to the exchange and use of infected propagating material. In the Southern and Middle-Eastern countries, the general situation of PPV seems still comfortable but the incumbent risk is related to importing infected varieties from abroad. Two of three PPV foci in Jordan were in peach and plum orchards established with propagating material coming from Europe. Other viruses and relative diseases are present, but their incidence in the South and Middle East is still lower than in European countries.

Updating phytosanitary legislation and diagnostic technology, implementing effective quarantine controls and prompt eradication of trees infected by quarantine agents, and establishing national certification programs, are essential issues for avoiding the introduction and spread of quarantine graft-transmissible diseases and favour the development of quality nursery and fruit tree industry.

ACKNOWLEDGEMENTS

The authors thank the following colleagues for kindly furnishing the data relative to their countries: drs. M. Al-Rwahnih (Jordan), J. Jawhar and E. Choueiri (Lebanon), S. Edhib and H. Zeramdini (Tunisia), F.Ismaeil (Syria), H.M. Sipahioglu (Turkey), M. Gatt (Malta), V. Pallás (Spain), S. Spiegel (Israel), D. Skoric (Croatia) and A. Shalaby (Egypt).

Table 2. Viruses in stone fruit trees among Mediterranean countries*

Country	Viruses frequently detected					Viruses less frequently detected	
	PPV	ACLSV	PDV	PNRSV	ApMV	Nepoviruses	Others
Albania	+	+	+	+			APLPV
Algeria		+	+	+	+		
Croatia	+	+	+	+		ArMV, SLRSV	
Cyprus	+	+	+	+			
Egypt	+	+	+	+		PRMV, ToRSV	
France	+	+	+	+	+	ALRSV, CLRV, MLRSV, RpRV, SLRSV, StPV	ApLV, APLPV, CGRMV
Greece	+	+	+	+	+		
Israel			+	+			
Italy	+	+	+	+	+	CLRV, SLRSV	ApLV, APLPV, CGRMV, CMLV, PBNSPaV
Jordan	+	+	+	+	+		
Lebanon		+	+	+			CGRMV
Malta		+	+	+			
Morocco			+	+			
Palestine		+	+	+			ApLV, APLPV
Portugal	+			+			
Slovenia	+		+	+			
Spain	+	+	+	+	+	RpRV, SLRSV,	CGRMV
Syria	+	+	+	+	+	SLRSV	
Tunisia		+	+	+	+		APLPV
Turkey	+	+	+	+		CLRV, PRMV, RpRV, SLRSV, ToRSV	
Fr.Yugoslavia	+	+	+	+			

* This information was in part due to efforts of MNFTV participants and from previous publications (Németh, 1986; Diekmann and Putter, 1996; Desvignes, 1999); + : virus presence. Full virus name not cited in the text: CGRMV-Cherry green ring mottle virus; CLRV-*Cherry leaf roll virus*; CMLV-Cherry mottle leaf virus; PRMV-*Peach rosette mosaic virus*; PBNSPaV-Plum bark necrosis stem pitting-associated virus; StPV-Stocky prune virus; ToRSV-*Tomato ringspot virus*.

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